

Claims

- [c1] 1. A multiphase centrifugal supercharging air induction system for supplying compressed induction fluid to an intake manifold of an internal combustion engine wherein the engine includes a rotatable crankshaft, said induction system comprising:
- a first centrifugal supercharger drivingly connectable to the crankshaft and operable to compress induction fluid for the engine,
- said first supercharger including a first inlet, a spaced first outlet, and a first impeller fluidly between the first inlet and first outlet to compress induction fluid;
- a second centrifugal supercharger drivingly connectable to the crankshaft and operable to compress induction fluid for the engine,
- said second supercharger including a second inlet, a spaced second outlet, and a second impeller fluidly between the second inlet and second outlet to compress induction fluid; and
- an induction fluid flow control assembly fluidly intercommunicating the superchargers so that the superchargers cooperatively provide induction fluid to the engine in a number of operating phases, including a first phase in which at least some induction fluid from the first outlet is supplied to the second inlet and a second phase in which at least some induction fluid from the first and second outlets is supplied to the intake manifold without passing through the other supercharger.
- [c2] 2. The system as claimed in claim 1; and
- a drive assembly operable to drivingly connect the superchargers to the crankshaft so that each of the superchargers operates continuously with rotation of the crankshaft.

- [c3] 3. The system as claimed in claim 2,
said first and second impellers being rotatable, each being operable to compress induction fluid for the engine when rotated,
said first and second superchargers including a transmission drivingly connecting the impellers to the drive assembly,
said transmission cooperating with the drive assembly to maintain rotation of the impellers at a substantially constant ratio relative to the rotation of the crankshaft.
- [c4] 4. The system as claimed in claim 3,
said transmission including a plurality of intermeshing gears with at least one of said gears being common to both superchargers.
- [c5] 5. The system as claimed in claim 4,
said transmission including a common rotatable transmission shaft coupled to said common gear,
said drive assembly including an endless element entraining at least a portion of said common shaft and being operable to entrain at least a portion of the crankshaft.
- [c6] 6. The system as claimed in claim 1,
said induction fluid flow control assembly fluidly intercommunicating the superchargers so that in all operating phases both superchargers compress at least some induction fluid for the engine whenever the crankshaft is rotating.
- [c7] 7. The system as claimed in claim 6,
said induction fluid flow control assembly being operable to fluidly intercommunicate the superchargers with the intake manifold so that in all operating phases substantially all of the induction fluid compressed by

each of the superchargers is delivered to the intake manifold.

- [c8] 8. The system as claimed in claim 1,
said first phase including a series phase in which substantially all
induction fluid from the first outlet is supplied to the second inlet.
- [c9] 9. The system as claimed in claim 8,
said first phase further including a first transition phase,
said induction fluid flow control assembly being configured to switch
operation of the superchargers from the series phase to the first transition
phase in response to a predetermined condition.
- [c10] 10. The system as claimed in claim 9,
said predetermined condition being the relative rotational speed of the
crankshaft measured in engine rpm relative to the maximum rotational
speed of the crankshaft,
said relative rotational speed being between about sixty and about
seventy percent of the maximum rotational speed.
- [c11] 11. The system as claimed in claim 1,
said second phase including a parallel phase in which substantially all
induction fluid from the first and second outlets is supplied directly to the
intake manifold.
- [c12] 12. The system as claimed in claim 11,
said second phase further including a second transition phase,
said induction fluid flow control assembly being configured to switch
operation of the superchargers from the second transition phase to the
parallel phase in response to a predetermined condition.
- [c13] 13. The system as claimed in claim 12,

said predetermined condition being the relative rotational speed of the crankshaft measured in engine rpm relative to the maximum rotational speed of the crankshaft,
said relative rotational speed being about eighty percent of the maximum rotational speed.

[c14] 14. The system as claimed in claim 1; and
a case presenting a compression chamber and a transmission chamber,
said first and second superchargers being at least partially housed within
said compression chamber.

[c15] 15. The system as claimed in claim 1,
said induction fluid flow control assembly including a passageway fluidly
communicating said first outlet and said second inlet,
said induction fluid flow control assembly further including a first valve
disposed along said passageway for controlling the flow of induction fluid
there through.

[c16] 16. The system as claimed in claim 15,
said first valve shiftable between an open position wherein induction fluid
can flow through said passageway and a closed position wherein
induction fluid is prevented from flowing through said passageway,
said first valve shiftable into a plurality of intermediate positions between
said open and closed positions wherein the quantity of induction fluid
allowed to flow through the passageway varies from one intermediate
position to another.

[c17] 17. The system as claimed in claim 15,
said induction fluid flow control assembly including an additional
passageway in fluid communication with said first outlet and operable to

be in fluid communication with the intake manifold,
said induction fluid flow control assembly further including a second valve
disposed along said additional passageway downstream of said first-
mentioned passageway for controlling the flow of induction fluid through
said additional passageway.

[c18] 18. The system as claimed in claim 17,
said second valve shiftable between an open position wherein induction
fluid can flow through said additional passageway and a closed position
wherein induction fluid is prevented from flowing through said additional
passageway.

[c19] 19. The system as claimed in claim 17,
said induction fluid flow control assembly including a second additional
passageway in fluid communication with said second inlet,
said induction fluid flow control assembly further including a third valve
disposed along said second additional passageway upstream of said first-
mentioned passageway for controlling the flow of induction fluid through
said second additional passageway.

[c20] 20. The system as claimed in claim 19,
said third valve shiftable between an open position wherein induction fluid
can flow through said second additional passageway and a closed
position wherein induction fluid is prevented from flowing through said
second additional passageway.

[c21] 21. The system as claimed in claim 19; and
a case presenting a compression chamber and a transmission chamber,
said first and second superchargers and said induction fluid flow control
assembly being at least partially housed within said compression

chamber,

said compression chamber presenting a case inlet in fluid communication with the atmosphere.

[c22] 22. The system as claimed in claim 21,
said induction fluid flow control assembly including a third additional passageway fluidly communicating the case inlet with said first inlet and fluidly communicating the case inlet with said second additional passageway,
said induction fluid flow control assembly further including a fourth valve disposed along said third additional passageway for controlling the flow of induction fluid there through.

[c23] 23. The system as claimed in claim 22,
said fourth valve shiftable between an open position wherein induction fluid can flow through said third additional passageway and a partially closed position wherein at least some induction fluid is prevented from flowing through said third additional passageway.

[c24] 24. A method of supplying compressed induction fluid to an intake manifold of an internal combustion engine of a powered land vehicle, wherein the engine includes a rotatable crankshaft and, when off idle, operates at variable rpm over a rev range, said method comprising the steps of:
(a) driving a first supercharger off of the crankshaft to compress induction fluid;
(b) driving a second supercharger off of the crankshaft to compress induction fluid;
(c) operating the superchargers at least partially in series so that at least some induction fluid that is compressed by the first supercharger is

further compressed by the second supercharger and then supplied to the intake manifold of the engine; and

(d) operating the superchargers at least partially in parallel so that at least a portion of induction fluid is compressed by the first supercharger and at least another portion of induction fluid is compressed by the second supercharger and the at least a portion and at least another portion of compressed induction fluid are supplied to the intake manifold of the engine without passing through the other supercharger.

[c25] 25. The method as claimed in claim 24,
step (d) being performed after step (c) so that operation of the superchargers phases from at least partially in series to at least partially in parallel in response to a predetermined condition,
said predetermined condition comprising the engine rpm being greater than about seventy percent of rev range.

[c26] 26. The method as claimed in claim 24,
step (d) being performed after step (c) so that operation of the superchargers phases from at least partially in series to at least partially in parallel in response to a predetermined condition; and
(e) switching operation of the superchargers to substantially fully parallel in response to a second predetermined condition so that at least a portion of induction fluid is compressed by the first supercharger and at least another portion of induction fluid is compressed by the second supercharger and the at least a portion and at least another portion of compressed induction fluid are supplied to the intake manifold of the engine without passing through the other supercharger wherein said at least a portion and said at least another portion of induction fluid comprise substantially all induction fluid supplied to the intake manifold of

the engine.

- [c27] 27. The method as claimed in claim 26,
said second predetermined condition comprising the engine rpm being
about eighty percent of rev range or higher.
- [c28] 28. The method as claimed in claim 24,
steps (a) and (b) each including the step of drivingly connecting the
superchargers to the crankshaft so that each of the superchargers
operates continuously with rotation of the crankshaft.
- [c29] 29. The method as claimed in claim 28,
steps (a) and (b) each further including the step of drivingly connecting
the superchargers to the crankshaft so that each of the superchargers
operates at a substantially constant ratio relative to the rotation of the
crankshaft.
- [c30] 30. The method as claimed in claim 28,
steps (a) and (b) including the common step of intermeshing a common
gear between the superchargers.
- [c31] 31. The method as claimed in claim 30,
steps (a) and (b) further including the common steps of entraining an
endless element around at least a portion of the crankshaft and driving
the common gear at least in part with the endless element.
- [c32] 32. The method as claimed in claim 24,
steps (c) and (d) each including the step of operating both superchargers
so that each supercharger compresses at least some induction fluid that
is supplied to the intake manifold of the engine whenever the crankshaft
is rotating.

- [c33] 33. The method as claimed in claim 32,
steps (c) and (d) each further including the step of delivering substantially
all of the induction fluid compressed by the superchargers to the intake
manifold.
- [c34] 34. The method as claimed in claim 24,
step (c) including the step of operating the superchargers substantially
fully in series so that substantially all induction fluid that is compressed by
the first supercharger is further compressed by the second supercharger
and then supplied to the intake manifold of the engine.
- [c35] 35. The method as claimed in claim 24; and
(e) housing both superchargers substantially within a case.
- [c36] 36. The method as claimed in claim 24; and
(e) intercommunicating the first and second superchargers and the intake
manifold,
step (e) including the steps of fluidly communicating the first and second
superchargers with a serial passageway and disposing a first valve along
the serial passageway for controlling the flow of induction fluid there
through.
- [c37] 37. The method as claimed in claim 36,
step (c) including the step of shifting the first valve into an open position
wherein induction fluid can flow through said serial passageway.
- [c38] 38. The method as claimed in claim 36,
step (d) including the step of shifting the first valve into a closed position
wherein induction fluid is prevented from flowing through said serial
passageway.

- [c39] 39. The method as claimed in claim 36,
step (e) including the steps of fluidly communicating the first supercharger and the intake manifold with an additional passageway and disposing a second valve along the additional passageway for controlling the flow of induction fluid there through.
- [c40] 40. The method as claimed in claim 39,
step (c) including the step of shifting the second valve into a closed position wherein induction fluid is prevented from flowing through said additional passageway.
- [c41] 41. The method as claimed in claim 39,
step (d) including the step of shifting the second valve into an open position wherein induction fluid can flow through said additional passageway.
- [c42] 42. The method as claimed in claim 39,
step (e) including the steps of fluidly communicating the second supercharger and the atmosphere with a parallel passageway and disposing a third valve along the parallel passageway for controlling the flow of induction fluid there through.
- [c43] 43. The method as claimed in claim 42,
step (c) including the step of shifting the third valve into a closed position wherein induction fluid is prevented from flowing through said parallel passageway.
- [c44] 44. The method as claimed in claim 43,
step (d) including the step of shifting the third valve into an open position wherein induction fluid can flow through the parallel passageway.

- [c45] 45. The method as claimed in claim 42,
step (e) including the step of fluidly communicating the atmosphere, the first supercharger, and the parallel passageway with an inlet passageway and disposing a fourth valve along said inlet passageway for controlling the flow of induction fluid there through.
- [c46] 46. The method as claimed in claim 45; and
(f) shifting the fourth valve into a partially closed position wherein at least some induction fluid is prevented from flowing through said inlet passageway.
- [c47] 47. In a powered land vehicle including an internal combustion engine having an intake manifold and a rotatable crankshaft, an improved air induction system comprising:
a first centrifugal supercharger drivingly connected to the crankshaft for compressing induction fluid for the engine,
said first supercharger including a first inlet, a spaced first outlet, and a first impeller fluidly between the first inlet and first outlet to compress induction fluid;
a second centrifugal supercharger drivingly connected to the crankshaft for compressing induction fluid for the engine,
said second supercharger including a second inlet, a spaced second outlet, and a second impeller fluidly between the second inlet and second outlet to compress induction fluid; and
an induction fluid flow control assembly fluidly intercommunicating the superchargers so that the superchargers cooperatively provide induction fluid to the engine in a number of operating phases, including a first phase in which at least some induction fluid from the first outlet is supplied to the second inlet and a second phase in which at least some

induction fluid from the first and second outlets is supplied to the intake manifold without passing through the other supercharger.

[c48] 48. In a powered vehicle as claimed in claim 47; and
a drive assembly drivingly connecting the superchargers to the crankshaft so that each of the superchargers operates continuously with rotation of the crankshaft.

[c49] 49. In a powered vehicle as claimed in claim 48,
said first and second impellers being rotatable to compress induction fluid for the engine when rotated,
said first and second superchargers including a transmission drivingly connecting the impellers to the drive assembly,
said transmission cooperating with the drive assembly to maintain rotation of the impellers at a substantially constant ratio relative to the rotation of the crankshaft.

[c50] 50. In a powered vehicle as claimed in claim 49,
said transmission including a plurality of intermeshing gears with at least one of said gears being common to both superchargers.

[c51] 51. In a powered vehicle as claimed in claim 50,
said transmission including a common rotatable transmission shaft coupled to said common gear,
said drive assembly including an endless element entraining at least a portion of said common shaft and at least a portion of the crankshaft.

[c52] 52. In a powered vehicle as claimed in claim 47,
said induction fluid flow control assembly fluidly intercommunicating the superchargers so that in all operating phases both superchargers compress at least some induction fluid for the engine whenever the

crankshaft is rotating.

- [c53] 53. In a powered vehicle as claimed in claim 52,
said induction fluid flow control assembly being operable to fluidly
intercommunicate the superchargers with the intake manifold so that in all
operating phases substantially all of the induction fluid compressed by
each of the superchargers is delivered to the intake manifold.
- [c54] 54. In a powered vehicle as claimed in claim 47,
said first phase including a series phase in which substantially all
induction fluid from the first outlet is supplied to the second inlet.
- [c55] 55. In a powered vehicle as claimed in claim 54,
said first phase further including a first transition phase,
said induction fluid flow control assembly being configured to switch
operation of the superchargers from the series phase to the first transition
phase in response to a predetermined condition.
- [c56] 56. In a powered vehicle as claimed in claim 55,
said predetermined condition being the relative rotational speed of the
crankshaft measured in engine rpm relative to the maximum rotational
speed of the crankshaft,
said relative rotational speed being between about sixty and about
seventy percent of the maximum rotational speed.
- [c57] 57. In a powered vehicle as claimed in claim 47,
said second phase including a parallel phase in which substantially all
induction fluid from the first and second outlets is supplied directly to the
intake manifold.
- [c58] 58. In a powered vehicle as claimed in claim 57,

said second phase further including a second transition phase,
said induction fluid flow control assembly being configured to switch
operation of the superchargers from the second transition phase to the
parallel phase in response to a predetermined condition.

[c59] 59. In a powered vehicle as claimed in claim 58,
said predetermined condition being the relative rotational speed of the
crankshaft measured in engine rpm relative to the maximum rotational
speed of the crankshaft,
said relative rotational speed being about eighty percent of the maximum
rotational speed.

[c60] 60. In a powered vehicle as claimed in claim 47; and
a case presenting a compression chamber and a transmission chamber,
said first and second superchargers being at least partially housed within
said compression chamber.

[c61] 61. In a powered vehicle as claimed in claim 47,
said induction fluid flow control assembly including a passageway fluidly
communicating said first outlet and said second inlet,
said induction fluid flow control assembly further including a first valve
disposed along said passageway for controlling the flow of induction fluid
there through.

[c62] 62. In a powered vehicle as claimed in claim 61,
said first valve shiftable between an open position wherein induction fluid
can flow through said passageway and a closed position wherein
induction fluid is prevented from flowing through said passageway,
said first valve shiftable into a plurality of intermediate positions between
said open and closed positions wherein the quantity of induction fluid

allowed to flow through the passageway varies from one intermediate position to another.

[c63] 63. In a powered vehicle as claimed in claim 61,
said induction fluid flow control assembly including an additional passageway in fluid communication with said first outlet and the intake manifold,
said induction fluid flow control assembly further including a second valve disposed along said additional passageway downstream of said first-mentioned passageway for controlling the flow of induction fluid through said additional passageway.

[c64] 64. In a powered vehicle as claimed in claim 63,
said second valve shiftable between an open position wherein induction fluid can flow through said additional passageway and a closed position wherein induction fluid is prevented from flowing through said additional passageway.

[c65] 65. In a powered vehicle as claimed in claim 63,
said induction fluid flow control assembly including a second additional passageway in fluid communication with said second inlet,
said induction fluid flow control assembly further including a third valve disposed along said second additional passageway upstream of said first-mentioned passageway for controlling the flow of induction fluid through said second additional passageway.

[c66] 66. In a powered vehicle as claimed in claim 65,
said third valve shiftable between an open position wherein induction fluid can flow through said second additional passageway and a closed position wherein induction fluid is prevented from flowing through said

second additional passageway.

[c67] 67. In a powered vehicle as claimed in claim 65; and
a case presenting a compression chamber and a transmission chamber,
said first and second superchargers and said induction fluid flow control
assembly being at least partially housed within said compression
chamber,
said compression chamber presenting a case inlet in fluid communication
with the atmosphere.

[c68] 68. In a powered vehicle as claimed in claim 67,
said induction fluid flow control assembly including a third additional
passageway fluidly communicating the case inlet with said first inlet and
fluidly communicating the case inlet with said second additional
passageway,
said induction fluid flow control assembly further including a fourth valve
disposed along said third additional passageway for controlling the flow of
induction fluid there through.

[c69] 69. In a powered vehicle as claimed in claim 68,
said fourth valve shiftable between an open position wherein induction
fluid can flow through said third additional passageway and a partially
closed position wherein at least some induction fluid is prevented from
flowing through said third additional passageway.